

information that changed the staff's approach was presented to the American National Standards Institute (ANSI) Z-21 Accredited Water Heater Subcommittee in November 1991. In March of 1992, staff formally requested that the ANSI subcommittee develop a performance standard designed to protect against flammable vapor ignition. (Tab A) The industry did not respond by undertaking standard development. Instead the Gas Appliance Manufacturers Association (GAMA) began to study the problem, ostensibly to determine whether there were geographic differences in injury rates. A study was also funded by GAMA to determine whether an 18 inch stand would prevent all ignitions of flammable vapors. When some fires were started, albeit in extreme conditions, the industry concluded that not all fires would be prevented and thereafter declined to consider elevating water heaters.

Instead of developing a product standard, as staff had requested, GAMA developed a consumer education program. The program is of excellent quality and the Commission has acknowledged this effort and voted to allow the use of the CPSC name and logo on certain publications and video tapes contained therein. However, the education program is not a "fix" for the problem, it is merely a means of informing consumers of the potential hazard.

#### Death and Injury Data:

##### CPSC Data:

The Directorate for Epidemiology presents 5-year fire, death, injury, and property damage averages for the period 1986-1991. (TAB B) Gas-fueled water heaters igniting flammable liquids are identified annually in only 20% of the 1,961 estimated annual fires associated with water heaters, but they account for 54% of the injuries (316), 44% of the of the deaths (17) and 30% of the property losses (\$26,339,000).

Typical injury scenarios fell into three categories; children playing with or near gasoline, gasoline being used as a solvent, or other gasoline spill or leak.

##### Other Data:

GAMA sponsored work done by A.D. Little Laboratories (included in the supplemental materials available in the Office of the Secretary) examined several data bases including CPSC's and identified scenarios related to the bathroom, utility room, and a combination garage and

basement.

No current building code allows water heaters to be installed in bathrooms; nevertheless, many such installations exist. The two scenarios identified included people becoming "soaked" during activity such as cleaning parts, car repair or fueling operations. When such a person enters the bathroom where a water heater is installed, the vapors fall like water from the clothing and an ignition occurs. The other bathroom scenario involved children becoming covered in paint or a petroleum product and being brought into the bathroom and placed in the bathtub to have the material removed using gasoline as a solvent.

The utility room was associated with two scenarios. One, with a spill outside the room containing the water heater such as in an adjoining garage. The other scenario involved a spill within the room. In these accidents, some activity such as playing, fueling, or other use is often involved.

The garage and basement accidents again involve storage and associated spills, use of gasoline as a solvent, refueling and activities of children. The A.D. Little report indicates that of a data base of 135 incidents involving ignition of flammable vapors by residential gas water heaters, only 27 were known to have occurred in a garage. While 31 of the incidents did not specify the room location, the report's analysis showed that, in incidents where the room location was specified, the garage was involved in 10 of 27 deaths, 5 of 33 injuries and 2 of 11 incidents in which there were both deaths and injuries.

#### Applicable Codes and Standards:

Staff is aware of two standards which impact ignition of flammable vapors:

- The National Fuel Gas Code, NFPA 54/ANSI Z-223.1 which requires that water heaters installed in residential garages have all burners and burner ignition devices located not less than 18 inches above the floor. §5.1.9. In addition at §5.1.8 there is a requirement that "gas appliances shall not be installed in any location where flammable vapors are likely to be present, unless the design, operation, and installation are such to eliminate the probable ignition of the flammable vapors."

- The ANSI Gas Water Heater Standard, ANSI Z21.10.1 requires a label warning of the risk of injury associated with ignition of flammable vapors.

Staff has noted that the NFPA 54 requirements for garage installations have recently been incorporated into all model building codes. Staff notes that adoption by the model building codes does not guarantee that the provisions will be incorporated into local building ordinances, where compliance is enforced. Even if local jurisdictions adopt these provisions, garages apparently represent only a portion of the problem. Staff also notes that even if all new construction of houses and commercial replacements of existing residential water heaters followed the practice of elevating water heaters in the garage, there is a large portion of the incidents that would not be addressed. Staff believes that there has been very poor adherence over the years (since 1959) that the requirement has been in the National Fuel Gas Code. Moreover, staff believes that the provisions for other than garage installations are virtually never enforced for residential installations.

Additionally, the Division of Human Factors notes that the label is likely to have limited effectiveness and is unlikely to be thought about during activities unrelated to the water heater like lawn mower filling, or other gasoline usages such as for cleaning purposes, even if the label has been read.

#### Engineering:

Feasibility of a Performance Standard: Work at the Engineering Sciences Laboratory (ESEL) and at the American Gas Association Laboratory, by A.D. Little, demonstrated that when a gas water heater is installed on the floor, one half gallon of spilled gasoline caused dangerous levels of vapor in the area of the water heater burner. Engineering Laboratory work demonstrated that even minor elevation of the water heater (6 inches) significantly reduced the vapor levels reached. At the full 18 inch elevation, good protection was observed. The A.D. Little work also demonstrated greatly improved performance by elevation, but the work was extended to demonstrate that two gallons spilled with a lot of air turbulence forcing the vapors into the water heater could result in conditions where fires were possible.

Not every installation provides enough space above the water heater to allow elevation and proper venting for standard water heaters. To

address this problem, ESEL tested the water heaters on the floor with a 14 inch high sheet-metal barrier sealed to the floor. Even a one gallon spill 18 inches from the center-line of the water heater (so close that without the barrier, the gasoline ran under it) resulted in levels of flammable vapors below those considered unsafe. When these results were shared with the industry, the most important questions raised were about the effect of the barrier on the combustion characteristics of the water heater (to see whether unsafe levels of CO would be released). To answer this question, ESEL tested the water heater with and without the barrier. The results in combustion characteristics were indistinguishable. Staff believes that the combined work by CPSC and A.D. Little demonstrate that new water heaters can be made much safer. The effect of a barrier such as that used by ESEL can be built into a new water heater.

**Feasibility of a Retrofit Method:** Engineering has demonstrated the feasibility of developing a method to retrofit water heaters already installed in residences. (Tab C) The method used by Engineering was very simple, a piece of sheet metal (roof flashing) 14 inches by 6 feet was taped together using duct tape to form a circle slightly larger than the water heater's circumference and was then taped to the floor. This action forced all air for combustion to be drawn over the 14 inch barrier created. As a result, very little air was drawn from near the floor. This performance can also be incorporated into new water heaters without restricting design options. In order to assist in the retrofit work staff was undertaking, GAMA supplied water heaters which had been tested by the Department of Energy for fuel efficiency. Five water heaters were received at the ESEL and were properly fueled and run to determine the normal exhaust gas velocities that were produced at the top of each water heater. (Tab C) A "typical" water heater was then fitted with a small fan, which was adjusted to produce the same exhaust gas velocity and thereby safely simulate the gas flow which is produced by the burner's fire in normal operation. Using the fan instead of a burning unit allowed the tests to be conducted with gasoline while minimizing potential risk to laboratory personnel. The unit was transported to the National Institute of Science and Technology (NIST), where it was installed in a fire test facility with the fan used to simulate normal operation. Several experiments were conducted where gasoline was spilled on the floor near the water heater (18 inches from its center). Gasoline vapor concentrations in the air were measured at several locations,

most importantly at the burner. The results were that the barrier provided significant protection against flammable vapor ignition.

#### Industry Activities:

The staff's greatest concern is an apparent unwillingness on the part of the water heater manufacturers to take a serious look at the potential deficiencies (of taking combustion air from near the floor) in the current design of water heaters.

As noted above, the water heater manufacturers, through GAMA, have elected to emphasize consumer education over product improvements which could reduce or eliminate the risk of flammable vapor ignition. While staff believes that GAMA's efforts in the consumer education area are commendable, staff has repeatedly noted that it is not a complete solution. In the January 19, 1994 briefing package in which staff recommended that the Commission grant permission to GAMA to use the CPSC name and logo on certain consumer information materials, staff stated that "Staff considers that this [consumer information campaign] is an important and significant contribution to reducing the death and injury incidents which involve flammable vapors around the home. However, staff believes that the program will be only partially effective unless combined with technical solutions" [emphasis added]. (Tab D) The Division of Human Factors had voiced a similar concern regarding labeling. Human Factors stressed that prominent warning labels are necessary, but also noted that "A warning label is not an acceptable substitute..." (Tab E). The Chairman of the ANSI Z-21 Committee received a letter from Factory Mutual Research, and shared that letter with CPSC staff. (Tab F). Therein, Factory Mutual expressed the same concerns about the industry approach of only initiating a consumer information campaign. "If it is easy to handle the flammable liquid indoors, it will be done by some individuals, no matter how many warning labels or education programs to which they are exposed . . . . Thus, the hazard [vapors in the home] cannot be eliminated. Therefore, it must be mitigated." Factory Mutual describes the approach taken by the industry as ". . . . a public relations response to a technical hazard. Or as the computer-oriented would say, we are trying to solve a hardware problem with a software solution."

#### Economic Analysis:

Market Information: Based on Department of Energy data, the

Directorate for Economic Analysis (EC) indicates (Tab G) that there are between 40 and 50 million homes in the U.S. that have gas water heaters. Current sales are about 3.5 million units annually, according to the American Gas Association, and replacement rates (between the 4th and 18th year of use, according to *Appliance Magazine*) suggest that an additional 10 million units may be in use by the end of this decade. The five manufacturers that dominate the gas water heater market account for an estimated 99% of production.

**Cost/Benefit Data:** The total estimated societal costs associated with incidents involving gas water heaters and the ignition of flammable vapors are \$344 million. These costs include deaths, injuries, and property damage. EC estimates that it would be cost-effective to spend from \$59 to \$74 per water heater for modifications that would eliminate virtually all incidents involving the ignition of flammable vapors.

**Options:**

1. Issue an advance notice of proposed rulemaking to develop a performance standard to reduce or eliminate the risk of death or injury from the ignition of flammable vapors.
2. Defer to the voluntary standards process and encourage ANSI and GAMA to proceed with developing adequate provisions for reducing or eliminating the risk of injury associated with gas water heaters igniting flammable vapors.
3. Pursue action under section 15 of the CPSA.

**Recommendation:**

There are significant numbers of severe injuries and deaths occurring from gas water heaters igniting flammable vapors that could be cost-effectively prevented by establishing a performance standard which would be adhered to in the manufacture and certification of gas water heaters. Staff notes that even though a request was made 2 years ago, no standard development work has been undertaken by the committee charged with such development. Therefore, staff recommends that the Commission exercise option 1 for new water heaters. Available information indicates that it is technically feasible to develop performance requirements to address this hazard. A draft ANPR appears at Tab H for Commission consideration.



U.S. CONSUMER PRODUCT SAFETY COMMISSION

WASHINGTON, D.C. 20207

March 6, 1992

Allan J. Callahan  
Manager, Standards Department  
American Gas Association Laboratories  
8501 E. Pleasant Valley Road  
Cleveland, OH 44131

Dear Mr. Callahan:

Enclosed, for use by you and the Water Heater Subcommittee's working group on flammable vapor ignition, is a position paper from the staff of the CPSC on the subject of the need for standards for preventing such ignition from water heaters.

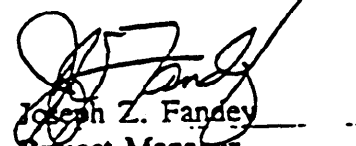
It is the position of the staff that ignition performance equal to or exceeding that achieved when a "standard" water heater is tested in an essentially draft free room at an elevation of approximately 18 inches (or another value which testing demonstrates to be needed) is a desirable goal. We would suggest that any standard developed be expressed in performance terms to eliminate any unessential design restriction.

The staff recognizes that the committee must consider only safety when making its decisions; nevertheless, the staff examined the benefits of preventing the deaths and injuries associated with the ignition of flammable vapors by water heaters. Staff estimates that net benefits would accrue to the consumer if the cost to implement any design changes was less than about \$40 to \$60.

Staff plans to participate fully with the working group and subcommittee in the examination of these issues and the development of test requirements and standards.

The views expressed in this letter (with enclosures) are those of the technical staff and not necessarily the official position of the Commission.

Sincerely,

  
Joseph Z. Fandey  
Project Manager,  
Gas Voluntary Standards

Enclosure





**CPSC Working Group on Gas  
Voluntary Standards**

**Position Paper On A  
Standard for Gas Water Heaters  
To Prevent Ignition of  
Flammable Vapors**

**FEBRUARY 1992**

## FLAMMABLE VAPOR IGNITION BY GAS WATER HEATERS

### BACKGROUND:

On April 4th, 1991, CPSC staff met with Edward Downing, an attorney practicing in Louisiana. At that meeting Mr. Downing presented injury information indicating that about 360 injuries, 20 deaths and \$16,000,000 in property loss were occurring annually from the ignition of flammable vapors by gas water heaters. These estimates mirrored CPSC's own data and were consistent with a 1975 study done for CPSC by Calspan. While staff was concerned with this problem over the years it accepted the position of the industry (as the industry recently reiterated in a meeting with staff) that the problem was not amenable to design fixes but was a result of a lack of consumer awareness of the hazard and knowledge of proper storage and handling of flammable vapors. Mr. Downing's presentation also included videotaped demonstrations of two design fixes which, under the conditions of the test, eliminated the ignition hazard. As a result of that presentation and a subsequent staff review of all available data, CPSC staff revised its plan to include encouraging the ANSI Z-21 subcommittee on Water Heaters to develop performance standards to reduce or eliminate the degree of hazard associated with currently produced (non-sealed combustion) water heaters installed at floor level.

On November 13th, 1991, Mr. Downing made a similar presentation before the ANSI Z-21 Water Heater subcommittee. In subsequent discussions the subcommittee made a commitment to form a working group to study the issue and work toward a performance standard. In support of that effort CPSC staff is providing the following information.

### DISCUSSION:

Injury Update - The most recent information available from the U.S. Fire Administration reports that there were an estimated 380 injuries, 30 deaths, and \$50.6 million in property loss associated with gas-fired water heaters in 1989. Twelve of the 30 deaths were associated with flammable vapors as were 75 percent of the injuries. A more complete discussion of this information is provided at Tab A.

Benefits Associated with the Prevention of Deaths, Injuries, and Property Damage - Using the annual average numbers of deaths and injuries associated with flammable vapor ignition by water heaters, the Directorate for Economic Analysis estimated the benefit which could

be achieved by eliminating this hazard (Tab B).

The estimation of the benefits considered the severity of burns the most frequently seen injury associated with this scenario. It also considered that three-fourths of current annual water heater production, estimated at 3.9 million units, is for replacement and one-fourth for new construction. Finally, the estimates considered that, if the entire production of gas water heater installations could be affected, and if the changes were fully effective injury reduction could accumulate at the rate of up to two deaths, 30 injuries and \$1.2 million in property damage each year. The estimated benefit expected per household could total \$40-\$60 over the expected 11-year life of the gas-fired water heater.

Effectiveness of labeling - The Human Factors Division has examined the possible effectiveness of labeling for preventing these injuries and concludes, at Tab C, that a warning label is not the solution to the hazard and should not be used as a substitute for a design change. However, because raising the water heaters will not eliminate the potential for the ignition of flammable vapors, consumers are still at risk and need to be warned of the potential hazard.

### CONCLUSION:

CPSC staff believes that it is technically feasible to reduce the hazards associated with flammable vapor ignition by water heaters. Mr. Downing suggested that an appropriate height is already in the NFPA standard for installation of water heaters in garages, 18 inches. However, whether an 18 inch height or its equivalent is necessary or even sufficient has not yet been determined. The CPSC staff therefore recommends that the subcommittee's working group examine various heights and make a determination of the actual performance requirement necessary to reduce or eliminate the existing hazard. Subsequently, it will be necessary to devise a test method whereby non-height related fixes can be evaluated and certified.

UNITED STATES GOVERNMENT  
MEMORANDUM

U.S. CONSUMER PRODUCT  
SAFETY COMMISSION  
WASHINGTON D.C. 20207

DEC 18 1991

TO : Joseph Z. Fandey, Manager, Gas Voluntary Standards  
Project

Through: Robert D. Verhalen, Associate Executive Director  
Directorate for Epidemiology  
Robert E. Frye, Director, EPHA

FROM : William Rowe, EPHA, 492-6470

SUBJECT: Fires from Gasoline Ignited by Gas Water Heaters

An estimated three-fourths of the reported deaths and injuries, and over half of the property losses from flammable vapor fires ignited by water heaters involve gasoline vapor and gas water heaters (see the attached table). The data included in this table are for 1989, the most recent year that is available from the U.S. Fire Administration's National Fire Incident Reporting System (NFIRS). In 1989, there were an estimated 30 deaths, 380 injuries, and \$50.6 million in property loss due to gas fired water heaters. The attached table shows an estimated 12 of the 30 deaths were due to flammable vapors (nine gasoline and three other vapors). About 75 percent of the injuries were related to gasoline vapors.

From October 1975 to November 1991 the Consumer Product Safety Commission (CPSC) conducted 41 in-depth investigations (IDI) involving the ignition of flammable vapors by gas water heaters. Only four of the 41 cases contain information on the height of the air intake. Among them, the highest air intake was estimated as 12 inches above the floor.

Discussion: \_\_\_\_\_

The hazard of gasoline vapor ignition by water heaters has often been seen as addressable through increasing consumer awareness of fire hazards associated with gasoline and improving gasoline storage containers. Raising the gas water heater air intake 18 inches above the floor through a voluntary standards effort should be encouraged to prevent gasoline vapor ignition by

gas water heaters. The pilot light and burner assembly of gas water heaters are at the bottom, and heaters are usually installed on or very close to the floor. Heavy flammable vapors, typically gasoline, stay close to the floor. If gasoline is spilled in the same room as a gas water heater the vapors can easily be drawn into the water heater and ignited. The hazard is very well demonstrated in a video tape shown to the staff in April 1991.

Attachment:

**Estimated Fire Deaths, Injuries, and Property Loss from  
Flammable Vapors Ignited by Water Heaters, 1989**

**Estimated Fire Deaths**

Type of Water Heater			Type of Flammable Vapor			
	<u>Total</u>		<u>Gasoline</u>		<u>Other</u>	
	No	%	No	%	No	%
Total	12	100	9	75	3	25
Gas Fuel	12	100	9	75	3	25
Other Fuel	0	-	0	-	0	-

**Estimated Fire Injuries**

Type of Water Heater			Type of Flammable Vapor			
	<u>Total</u>		<u>Gasoline</u>		<u>Other</u>	
	No	%	No	%	No	%
Total	374	100	281	75	93	25
Gas Fuel	349	93	272	73	77	20
Other Fuel	26	7	9	2	16	4

**Estimated Property Loss (in Thousands)**

Type of Water Heater			Type of Flammable Vapor			
	<u>Total</u>		<u>Gasoline</u>		<u>Other</u>	
	No	%	No	%	No	%
Total	\$19,400	100	\$14,300	73	\$5,170	27
Gas Fuel	\$15,700	81	\$12,500	64	\$3,200	17
Other Fuel	\$3,700	19	\$1,800	9	\$1,970	10

Source: U.S. Consumer Product Safety Commission/EPHA from data obtained from the National Fire Protection Association and the U.S. Fire Administration

UNITED STATES GOVERNMENT  
MEMORANDUM

U.S. CONSUMER PRODUCT  
SAFETY COMMISSION  
WASHINGTON, D.C. 20207

8 JAN 1992

TO: Joseph Z. Fandey, ESEE, Project Manager, Gas Voluntary  
Standards  
Through: William W. Walton, AED, ES <sup>W3</sup>  
Through: Warren J. Prunella, AED, EC <sup>WJP</sup>  
FROM: Elizabeth W. Leland, ECPA, 504-0962 <sup>en 2</sup>  
SUBJECT: Benefits of Preventing Accidents Associated with  
Flammable Vapor Ignition by Gas-Fired Water Heaters

Every year, an estimated 20 deaths, 360 injuries, and \$15 million in property damage are associated with fires that start when flammable vapors are ignited by gas water heaters. The burn injuries from these fires are severe and require major long-term medical treatment.

A proposal to the building codes and standards to change the design or location of water heaters potentially could eliminate the risk of these accidents, and up to two deaths, 30 injuries, and \$1.2 million in property damage could be avoided each year. The estimated expected benefits per household over the life of the product could total from about \$40 to about \$60.

## I. Introduction

This memorandum provides information about the benefits of preventing accidents associated with the ignition of flammable vapors by gas-fired water heaters. The injury and property damage information is based on data from the National Fire Protection Association (NFPA) and the U.S. Fire Administration (USFA). Industry sources provided information about the severity of the injuries, the costs associated with hospitalization, medical treatment, and lost wages, and the dollar amounts of related jury verdicts and legal settlements. Information about the market for water heaters was obtained from the trade press.

## II. Background

In some homes, flammable liquids, such as gasoline, household solvents, and paint thinners, are stored in the same location as the household's gas-fired water heater. Gas-fired water heaters operate by taking in room air about two inches from the floor and passing it over a pilot flame; it is possible that

vapors from flammable liquids can be taken in with the room air, especially when the flammable liquid has been spilled or left exposed to the air. When this happens, the vapors can be ignited and a fire or explosion can occur.

In 1980, the American National Standards Institute (ANSI) adopted into its Z223.1 standard a requirement that gas utilization equipment, including water heaters, should not be installed in any location where flammable vapors likely would be present unless the design, operation, and installation of the water heater was such that the probable ignition of the vapors would be eliminated. The National Fuel Gas Code similarly states that the burners and burner ignition devices of gas utilization equipment that is installed in residential garages should be at least 18 inches above the floor. The CPSC staff is considering submitting to the National Fuel Gas Code a proposal to extend this requirement to the entire residence and a proposal to ANSI to change the voluntary standard for water heaters to provide similar protection.

### III. Number and Severity of Injuries

There are two readily-available sources of information concerning the number of injuries and deaths associated with the ignition of flammable vapors by gas-fired water heaters. A report prepared by the NFPA in 1987 for a law firm in Metairie, Louisiana, discussed the origin during 1980-1984 of residential structural fires involving flammable and combustible liquids.(1) According to this report, 2,034 fires, 21 deaths, 361 injuries, and \$16 million in direct property damage occurred each year during that period as a result of ignition of flammable vapors by gas-fired water heaters.(2)

The other source of information is an estimate provided by the CPSC Directorate for Epidemiology based on data from the NFPA and the USFA. According to the Directorate for Epidemiology, 12 deaths, 374 injuries, and \$19 million in property damage occurred in 1989, the most recent year for which data are available.(3) This estimate includes deaths, injuries, and property damage associated with the ignition of flammable vapors by gas-fired water heaters.

The predominant injury associated with these fires is a burn. Information about the severity of the burns resulting from these types of accidents consists of documents from 15 legal cases in which the Metairie, Louisiana law firm represented plaintiffs.(4) Correspondence from the law firm indicates that in those 15 cases the burns were mostly second- and third-degree and covered from 17 to 100 percent of the body.

Of the 15 people who were injured, one suffered burns to 17 percent of his body, four suffered burns to 30 to 50 percent of their bodies, five suffered burns to 50 to 90 percent of their bodies, and four suffered burns to 90 percent or more of their



bodies. The ages of the injured ranged from 14 months to 37 years old. Eleven of the 15 victims were children under the age of five years, one was a seven-year-old child, and three were persons over 30 years old.

#### IV. Cost of Injuries

According to a report prepared for Congress,

"a severe burn is considered by many to be the most devastating injury a person can survive. Numerous studies of severely burned patients point to the deep and complicated emotional reactions that accompany burns. Facial disfigurement caused by a severe burn potentially alters consciousness more drastically and creates more serious emotional problems than other forms of disability because the face represents oneself, one's essential being, more than any other part of the body. (6)

Burn victims must confront not only medical costs, but also lost wages as a result of time away from work and emotional costs associated with changes in personal relationships. Information concerning the total dollar value of the costs for burns resulting from accidents involving the ignition of flammable vapors by gas-fired water heaters is not readily available; however, there is some information from three cases litigated by the Metairie, Louisiana, law firm which indicates that the present value of lost wages alone approximated \$700,000. (7)

Additional information from Personal Injury Valuation Handbooks about three other cases involving the types of burns suffered by the individuals involved in these accidents indicates that the jury verdicts in each case were \$2 million, \$3 million, and \$10 million. (8) In addition, a 1988 study of burn injuries and verdicts for a five-year period indicated that 22 percent of the awards ranged from \$100,000 to \$299,000 and 35 percent of the awards were \$1 million or more. (9) Information from the cases litigated by the Louisiana law firm indicate that one settlement totalled \$7.2 million; all other settlements were at least \$1 million. (10)

#### V. Product Market Information

According to Appliance magazine, the average product life of a gas-fired water heater is 11 years. In 1990, about 48 million, or 53 percent of United States households had gas-fired water heaters. Sales in 1990 totalled 3.9 million; of these, it is estimated that 2.9 million were sold for replacement and that 1.0 million were sold for new homes. (11)

## VI. Benefits Associated with the Prevention of Deaths, Injuries, and Property Damage

The dollar value of the benefits associated with the prevention of deaths, injuries, and property damage will depend on how any change made to the installation and building codes is implemented. Reportedly, there are several methods available to prevent deaths, injuries, and property damage from these types of accidents, including changing the physical design and location of the air inlet on the water heater, adding a flame break, or placing the water heater on a stand so that the air inlet is higher off the floor.

Installation and building codes generally apply to new construction; however, if manufacturers were to change the physical design or location of the water heater, then it is likely that all new water heaters on the market would be changed, whether intended for the replacement market or for the new housing market. In this case, then, nearly four million households purchasing new water heaters potentially could be affected by the change to the building and installation codes. If the changes were fully effective, then about two deaths, 30 injuries, and \$1.2 million in property damage would be avoided each year.

If the change to the building and installation codes were implemented to apply to only those water heaters being installed in new homes, then potentially one million households could be affected. If the changes were fully effective, then about one death, eight injuries, and \$315,000 in property damage would be avoided each year.

## VII. Dollar Value of the Benefits of Preventing Deaths, Injuries, and Property Damage

The dollar value of the benefits accruing from the prevention of deaths, injuries, and property damage can be estimated using the information described above about injury costs, jury verdicts, and awards. The estimated dollar value of total benefits from the elimination of all deaths, injuries, and property loss associated with these types of accidents ranges from about \$160 million to about \$180 million. These estimates are based on the following: a consensus statistical value of life of \$2 million, discount rates of 5 percent and 10 percent, an estimated average injury cost of \$600,000, (12) the assumption that changes are made to the design of water heaters so that about 4.0 million households are affected, and the assumption that the changes made to the water heaters are fully effective in reducing deaths, injuries, and property damage. The estimated expected benefits per household could total from \$40 to \$50 over the life of the product.

Under the same assumptions as above excepting that only those 1.0 million new homes constructed with new water heaters would be affected, the estimated dollar amount saved from the elimination of the deaths, injuries, and property damage would range from about \$50 million to about \$60 million. The estimated expected benefits per household could total from \$50 to \$60 over the life of the product.

Thus, under the latter assumptions, any cost less than about \$50 to \$60 to implement changes to the design or location of water heaters would yield net benefits to the consumer. Under the former assumptions, net benefits would occur if the cost to implement the changes was less than about \$40 to \$50.

#### FOOTNOTES

- 1/ Kenneth T. Taylor, National Fire Protection Association, Special Report, Residential Structure Fires Involving Flammable, Combustible Liquids, 1980-1984 Fire Experience, July 1987.
- 2/ ibid. These data also are reported in Gauthier, Wendell H., Murphy, Robert M., Downing, Edward F., III, Water Heaters and Flammable Vapors, Gauthier & Murphy, Metairie, Louisiana, p.6.
- 3/ "Fires from Gasoline Ignited by Gas Water Heaters," memorandum from William Rowe, EPHA, U.S. Consumer Product Safety Commission, to Joseph Z. Fandey, Project Manager, Gas Voluntary Standards Project, December 13, 1991.
- 4/ Correspondence from Edward F. Downing, III, Gauthier & Murphy, to Mr. Joe Fandey, U.S. Consumer Product Safety Commission, October 19, 1991.
- 5/ idem.
- 6/ Dorothy P. Rice, Ellen J. Mackenzie, and Associates, Cost of Injury in the United States, A Report to Congress, 1989, pp. 153-156.
- 7/ Correspondence from Edward F. Downing, III, Gauthier & Murphy, to Joseph Fandey, op. Cit.
- 8/ Jury Verdict Research, Inc., Personal Injury Valuation Handbooks, "Burns", p.6. These three cases did not involve the ignition of flammable vapors by gas-fired water heaters, but did involve similar injuries. Two of the cases involved second and third degree burns over two-thirds and 80 percent, respectively, of the victims' bodies and the third case involved severe burns and facial scarring.
- 9/ ibid., P. 2.
- 10/ Telephone conversation between Gauthier & Murphy and Joseph Z. Fandey, ESEE.
- 11/ Dana Chase Publications, Appliance, April 1991.
- 12/ This estimate is based on the material from the Personal Injury Valuation Handbooks. Previous research and studies by the Directorate for Economic Analysis about the costs of lifetime medical care associated with similar types of injuries indicates that this estimate may be conservative.

UNITED STATES GOVERNMENT  
MEMORANDUM

U.S. CONSUMER PRODUCT  
SAFETY COMMISSION  
WASHINGTON, D.C. 20207

NOV 21 1991

TO : Joseph Z. Fandey, Project Manager, ESEE  
Through: Dr. Robert D. Verhalen, Associate Executive Director *B. Verhalen*  
Directorate for Epidemiology  
Jacqueline Elder, Acting Director, EPHF *J. Elder*  
FROM : George Sweet, EPHF, 492-6468 *GS*  
SUBJECT: Gas Water Heaters

Human Factors was asked to comment on the recommendation that air intake openings on gas water heaters be raised above the floor. Human Factors was also asked to provide input on the use of warning labels on gas water heaters to address the potential for ignition of flammable vapors.

Background

Fires have been started by flammable vapors coming into contact with the pilot light of gas water heaters. In most cases, the air intake openings on gas water heaters are at floor level. Flammable vapors are usually denser than air and therefore, stay near the floor. The vapors can travel significant distances across a floor. Flammable vapors enter the water heaters at the air intake openings which delivers the air flow to the burners. If the vapors reach the air intake openings and come into contact with the pilot light, they are ignited. Recommendations have been made to raise air intake openings above the floor as a means of preventing flammable vapor fires.

Discussion

Raising the air intake openings on gas water heaters appears to promote fire prevention. Logically, it follows that raising the air intake openings would reduce fires occurring from the ignition of flammable vapors because it would be less likely that the dense vapors would rise a sufficient height to enter the water heater through the air intake openings. However, it is not a complete solution, and additional research is required to determine the height that best reduces the potential of vapors being ignited.

A warning label is not an acceptable substitute for raising air intake openings off the floor. It is important that a warning label be placed on the product, however, the warning label is not the solution to the problem, it is an identification of the problem to the consumer. Even though raising the air intake opening should decrease the potential of fires, it will not eliminate the potential for fires. It is conceivable that consumers will perceive the change of height as a complete solution to the problem, resulting in a false sense of security. The consumer must still be warned of the dangerous combination of gas water heaters and substances with flammable vapors. The warning label must be noticeable, easily understandable, and provide complete information in order to be effective. The warning label should be conspicuous, not blending in with the instructions.

### Conclusion

Human Factors supports raising the air intake openings of gas water heaters to decrease the potential for fires caused by the ignition of flammable vapors. Even with the adjusted height, it is essential that warning labels be conspicuously placed on gas water heaters to inform consumers of the potential fire hazard when products with flammable vapors are kept in proximity to a gas water heater. Additional research is required to determine the ideal height for the air intake openings in order to enhance fire prevention.





United States  
**CONSUMER PRODUCT SAFETY COMMISSION**  
Washington, D.C. 20207

**MEMORANDUM**

**DATE:** May 9, 1994

**TO :** Joseph Z. Fandey  
Project Manager Gas Voluntary Standards, ESEE

**Through:** Robert E. Frye  
Director, Hazard Analysis Division (EPHA) *RF*

**FROM :** William L. Rowe, EPHA (301) 504-0470, ext. 1271 *W. Rowe*

**SUBJECT:** Summary of Data on Gas-Fueled Water Heaters and Flammable Vapors

Attached is a table summarizing national gas-fueled water heater data. These data are the annual averages based on 1986 through 1991; 1991 is the most recent available year. The data appear to suggest that gasoline and other flammable liquids, in bold on the accompanying table, accounted for:

- ▶ Twenty percent (1,961 incidents) of the fires associated with gas-fueled water heaters.
- ▶ Fifty-four percent (316 people) of the injuries associated with gas-fueled water heaters.
- ▶ Forty-four percent (17 people) of the deaths associated with gas-fueled water heaters.
- ▶ Thirty percent (\$26,339,000) a third of the property loss associated with gas-fueled water heaters.

The importance of gasoline and other flammable liquids was also observed when the location of the fires was reviewed. During the same six years, 46 percent of these fires were in garages.

**Attachment**

**cc:**  
Dr. Verhalen



There were three primary hazards scenarios, based on a review of 42 recent Epidemiological Investigations, that resulted in the ignition of flammable vapors by gas water heaters: children playing, use of gasoline as a solvent, and spills and leaks.

#### **Children Playing**

A 2-year old male died from thermal burns sustained when a water heater ignited gasoline as he played in the utility room near a plastic gasoline container which melted in the fire.

An 8-year old female was staying with her grandparents, and opened the outside door to the utility room where gasoline was stored for a lawn mower. There was an explosion that self extinguished. She died at a burn center two weeks later. The gas company had mailed leaflets to all their customers warning customers about storing combustibles too close to their water heaters.

A 2-year old male died of burns after 2 days in the hospital. He had been using a riding toy in the basement while his mother was cleaning there. She saw him standing in a puddle holding a one gallon can of gasoline. The vapors then reached the water heater and ignited burning the boy and his clothing.

#### **Gasoline as a Solvent**

A 9-month old son, his 26-year old father, and his 22-year old mother died of burns from gasoline vapor ignited by the water heater. It was located in the kitchen of their basement apartment where the father was cleaning automotive parts with an open container of gasoline.

A 42-year old female was using gasoline to remove carpet backing from the floor of a newly purchased home. The gasoline was ignited by the gas water heater 20 feet from her. She died 23 days later.

A 17-year old male sustained 2° burns from gasoline and was hospitalized for five days. He was cleaning paint brushes with gasoline near a gas water heater.

#### **Gasoline Spill or Leak**

An 80-year old female was admitted to the hospital for smoke inhalation suffered in a house fire. The fire resulted from a dog knocking over a can of gasoline on the porch.

A 14-year old male was hospitalized with 60 percent 3° burns. He disconnected the fuel line of his motorcycle in the basement. The leaking gasoline was ignited by the water heater.

cc: Dr. Verhalen

Attachment